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Legal Aspects of Ecosystem Protection in the Context of Growing Urbanisation

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Abstract

The purpose of the study was to identify ways to improve the effectiveness of legal mechanisms for protecting urban ecosystems in the context of growing urbanisation and to develop recommendations for improving environmental legislation, considering international experience, current environmental challenges. The study was based on a systematic analysis of international and national legislation, a study of practical experience in implementing environmentally friendly solutions, and an assessment of the effectiveness of environmental control mechanisms in the EU, including Lithuania, Ukraine. The study found that modern cities, occupying only 3% of the earth's surface, are responsible for producing 50% of global waste, about 70% of greenhouse gas emissions and 75% of energy and natural resource consumption. It was found that in some large EU agglomerations, such as Milan and Paris, the level of nitrogen dioxide air pollution often exceeds the established limits, and about 90% of urban residents are exposed to polluted air. An analysis of demographic transformations has shown that Ukraine's population could decline by 21-31% by 2052, with the demographic burden ratio increasing from 50 to 70 dependents per 100 people of working age. A comparative analysis of the environmental policies of Ukraine and Lithuania has revealed significant differences in approaches to protecting urban ecosystems. Lithuania has already made significant progress in implementing European environmental standards, while Ukraine's implementation of similar policies remains less advanced. A study of successful practices in European cities has shown that in Germany, the annual increase in the area of green roofs is 13.5 million m2, and in Copenhagen, 200,000 m^2 of green roofs were created in 2010-2011 alone.

Keywords

Environmentally friendly solutions; Urban planning; Environmental standards; Green infrastructure; Anthropogenic load; Regulation

Introduction

The problem of legal protection of ecosystems in the context of growing urbanisation is becoming increasingly relevant in the modern world and requires a comprehensive, systematic approach to its solution. The rapid expansion of cities leads to environmental degradation, loss of biodiversity, water, air and soil pollution, which threatens environmental stability and public health. In these circumstances, legal mechanisms play a crucial role in ensuring a balance between economic growth and ecosystem conservation, as they form the fundamental basis for implementing environmental protection measures. The need to integrate environmental legislation into urban development strategies is becoming increasingly evident in the face of global challenges such as climate change and the rapid depletion of natural resources.

Scientific research in recent years has convincingly emphasised the need to introduce effective legal mechanisms for the preservation of ecosystems in the context of urbanisation, which is supported by numerous empirical data and theoretical developments. In particular, Lisina *et al.* (2024) point out the importance of legal regulation for improving air quality in urban agglomerations. Their in-depth research shows that the implementation of comprehensive regulations can significantly reduce the negative impact of urbanisation on ecosystems and human health. They emphasise that without a proper legal framework, air pollution control will be insufficient, which can lead to environmental degradation in densely populated areas and cause irreversible environmental consequences.

In the context of this issue, special attention should be paid to the study by Garba *et al.* (2024), who studied the impact of urbanisation on vegetation cover in Nigeria using spatio-temporal analysis. The authors found that the rapid expansion of cities leads to significant losses of natural resources, which is especially noticeable in regions with insufficient environmental legislation. Based on their findings, they recommend the integration of legal mechanisms into local governance to preserve biodiversity. An important contribution to the development of this issue was made by Corraini, Garcia Scherer and Rangel-Buitrago (2024), who proposed an innovative approach to coastal zone management in the context of urbanisation based on priority ranking. Their fundamental research showed that legal mechanisms are the basis for protecting coastal ecosystems from the negative impacts of urban development. Similar attention to water resources was paid by Margono, Hadi and Hidayat (2024), who conducted a comprehensive analysis of the legal aspects of aquatic ecosystem management. The authors convincingly emphasise that active involvement of communities in the formation of legal decisions ensures the long-term sustainability of ecosystems and creates an effective system of their protection.

Of considerable scientific interest is the research by Dewantoro, Hidayat and Mulyawati (2024), who focused on land use issues in urban areas, focusing on legal conflicts arising from the rapid expansion of urban areas. Their in-depth study demonstrates that clear legal regulation can help resolve these conflicts while minimising the negative impact on ecosystems. In this context, the findings of Kang *et al.* (2024), who studied the conservation of wetlands, which are important ecosystems in urban areas. The authors

argue that legal approaches to managing these areas are key to ensuring their functionality even in the face of urbanisation.

Suresh (2024) has carried out a comprehensive analysis of the impact of climate change and urbanisation on natural ecosystems, focusing on the integration of environmental legislation into a wide range of legal initiatives. His thorough conclusions convincingly confirm that without a comprehensive approach to legal regulation, it is impossible to ensure the sustainability of ecosystems in the current environment. In turn, Fatma and Danile (2024) conducted a comprehensive analysis of the legal aspects of regulating industrial expansion, emphasising that adapting legislation to the realities of urbanisation can significantly reduce the negative impact on the environment and promote the sustainable development of urban areas. A significant contribution to the development of the studied issues was made by Khan and Ullah (2024), who thoroughly investigated the challenges of marine ecosystem protection in the context of international cooperation. The authors argue that legal initiatives aimed at protecting marine resources should be integrated into global development strategies. In parallel, Rajabi, Mirabi and Moradi Shahdadi (2024) developed and proposed an innovative model of sustainable ecotourism that organically combines economic benefits with environmental goals. Their comprehensive study convincingly highlights that an appropriate legal framework can help protect natural areas while supporting economic development and ensuring balanced environmental management.

Particularly noteworthy are the findings of Albat, Alsaman and Albakjaji (2024), who focused on a comprehensive analysis of Saudi Arabia's environmental legislation. They argued that the adaptation of local legal mechanisms to global challenges, such as climate change and urbanisation, is critical for the preservation of desert ecosystems. Their systematic approach convincingly demonstrates that even in challenging geographical conditions, effective legal regulation can be a crucial factor in ensuring the sustainability of the natural environment and maintaining ecological balance. These studies convincingly confirm the importance of a comprehensive approach to the legal protection of ecosystems in the context of urbanisation. Integration of environmental legislation into urban planning, effective cooperation between communities and governments, and global coordination of efforts are key aspects for maintaining ecological balance in the context of rapid urban development and ensuring sustainable development of urban areas (Komilova *et al*., 2023; Lyubchik *et al*., 2008; Yermukhanova *et al*., 2017).

The purpose of the article is to determine the effectiveness of legal mechanisms for ecosystem protection, to establish their compliance with the current challenges of urbanisation, and to substantiate scientific and practical recommendations for improving environmental legislation. The objectives of the study were:

1. To reveal the theoretical and methodological foundations of legal regulation of ecosystem protection in the urban environment,
2. To describe the current state of legal support for the protection of ecosystems in the context of urban development
3. To substantiate the strategic directions for improving the legal regulation of ecosystem protection, given the challenges of urbanisation,

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Materials and Methods

Data Collection

The policy analysis is based on a comprehensive range of sources, including international and national legal frameworks, urban planning documents, statistical data, analytical reports, and scientific publications related to the protection of urban ecosystems. The theoretical basis of the study was formed by EU directives that reflect modern approaches to the legal regulation of ecosystem protection, in particular: Council Directive No. 92/43/EEC "On the Conservation of Natural Habitats and of Wild Fauna and Flora" (1992), which establishes the basic principles of biodiversity protection and defines the criteria for the establishment of protected areas; Directive of the European Parliament and of the Council No. 2000/60/EC "Establishing a Framework for Community Action in the Field of Water Policy" (2000), which regulates water management standards and sets requirements for water quality in urban agglomerations; Directive of the European Parliament and of the Council No. 2002/49/EC "Relating to the Assessment and Management of Environmental Noise – Declaration by the Commission in the Conciliation Committee on the Directive Relating to the Assessment and Management of Environmental Noise" (2002), which defines methods for assessing acoustic pollution and measures to reduce it; Directive of the European Parliament and of the Council No. 2008/50/EC "On Ambient Air Quality and Cleaner Air for Europe" (2008), which sets limits for pollutants and mechanisms for air monitoring. The strategic vision for the development of EU environmental legislation is presented in the European Green Deal (2019) and the Biodiversity Strategy for 2030 (2020), which define long-term goals and mechanisms for achieving them in the field of environmental protection. The national legislation is studied through the prism of the systemic Law of Ukraine No. 1264-XII "On Environmental Protection" (1991),[1] Law of Ukraine No. 3038-VI "On Regulation of Urban Development" (2011), [2]Law of Ukraine No. 2059-VIII "On Environmental Impact Assessment" (2017),[3] as well as bylaws in the field of environmental regulation and urban development. The legal framework of Lithuania is studied based on the analysis of the basic Law of the Republic of Lithuania No. I-2223 "On Environmental Protection" (1992),[4] Law of the Republic of Lithuania No. I-1120 "On Territorial Planning" (1995)[5] and Law of the Republic of Lithuania No. I-301 "On Protected Areas" (1993),[6] as well as Lithuania's Draft Updated National Energy and Climate Plan (2023).[7]

[1] Law of Ukraine No. 1264-XII "On Environmental Protection". (1991). Available online at: https://zakon.rada.gov.ua/laws/show/1264-12
[2] Law of Ukraine No. 3038-VI "On Regulation of Urban Development". (2011). Available online at: https://zakon.rada.gov.ua/laws/show/3038-17
[3] Law of Ukraine No. 2059-VIII "On Environmental Impact Assessment". (2017). Available online at: https://zakon.rada.gov.ua/laws/show/2059-19
[4] Law of the Republic of Lithuania No. I-2223 "On Environmental Protection". (1992). Available online at: https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/6378f2b0023211e6bf4ee4a6d3cdb874
[5] Law of the Republic of Lithuania No. I-1120 "On Territorial Planning". (1995). Available online at: https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/dde75b13095011e78dacb175b73de379?jfwid
[6] Law of the Republic of Lithuania No. I-301 "On Protected Areas". (1993). Available online at: https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.300377?jfwid=bkaxmpqm
[7] Lithuania's Draft Updated National Energy and Climate Plan. (2023). Available online at: https://commission.europa.eu/system/files/2023-12/Factsheet_Commissions_assessment_NECP_Lithuania_2023.pdf [Accessed on 16 April 2025]

An important source of empirical data was the statistical materials and analytical reports of the European Environment Agency (2020; 2021), which contain indicators of the state of the environment in European cities, and the study of the Joint Research Centre of the European Commission (2023) on demographic transformations in Ukraine. To analyse the practical implementation of environmental initiatives, the research materials on the effectiveness of nature-based solutions in EU cities (Oral *et al.*, 2020), reports on the results of green technology implementation (Burszta-Adamiak and Fiałkiewicz, 2019), as well as local regulations and urban planning documentation of European cities that successfully implement environmental modernization programmes, such as Copenhagen's experience in implementing green roofs and the experience of German cities[8] in creating low-emission zones, were used.

The methodological basis of the study is based on the integrated application of general scientific and special legal methods, which allowed for a comprehensive analysis of the problem of legal protection of urban ecosystems. Using the system analysis and the method of theoretical generalisation, the author examined the concept of sustainable development and modern approaches to understanding urban ecosystems, including the concepts of "nature-based solutions", "green infrastructure", and "green corridors", which helped to form the methodological basis of the study. The systemic method was used to consider legal mechanisms as an integral system of interconnected elements, which allowed identifying internal links between different levels of legal regulation and assessing their cumulative impact on the urban environment.

Data Analysis

The comparative legal method was used to compare the EU regulatory framework with Ukrainian and Lithuanian legislation, as well as to identify the specifics of the implementation of EU environmental standards in the national legal systems of both countries. The method of legal hermeneutics is used to interpret the content of legal provisions and analyse their compliance with modern urbanisation challenges. The modelling method was used to develop a table of specific measures and indicators for improving legal regulation, which allowed creating a comprehensive model for assessing the effectiveness of legal mechanisms.

The case study method was used to analyse specific examples of the implementation of environmental initiatives in European cities – in particular, the experience of Milan and Paris in controlling air pollution levels, the practice of introducing green roofs in Copenhagen and German cities, the creation of low-emission zones in Germany and air pollution reduction programmes in Northern European cities, as well as the experience of the Lithuanian cities of Vilnius and Kaunas in implementing nature-based solutions and environmental modernization of urban infrastructure – which made it possible to assess the effectiveness of the legal mechanisms. The selection of cities such as Milan, Paris, and various German cities was based on their established successes in implementing urban sustainability initiatives, offering valuable examples of best practices. However, the

[8] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions No. COM/2021/400 "Pathway to a Healthy Planet for All EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil'". (2021). Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021DC0400 [Accessed on 23 May 2024]

exclusion of failed initiatives or challenges in implementing legal mechanisms may limit the study's ability to provide a more comprehensive and balanced analysis of the complexities and potential pitfalls in urban ecosystem protection.

Economic analysis methods, including cost-benefit analysis, ROI (Return on Investment) calculations, and sensitivity analysis, were employed to evaluate the effectiveness of economic mechanisms aimed at stimulating environmental initiatives. This involved assessing the costs and benefits associated with the implementation of various environmental measures, such as energy-efficient infrastructure and waste management solutions, to determine their long-term economic viability and environmental impact. The statistical method was used to process quantitative data on the state of urban ecosystems, and the prognostic method was used to develop scientifically based recommendations for improving legal regulation. The interdisciplinary approach ensured that the legal, environmental, social and economic aspects of the problem under study were considered.

The study was implemented in three successive stages, each of which had its specific objectives and methodological features. At the first, theoretical and methodological stage, the research analysed the conceptual foundations of legal regulation of ecosystem protection, studied the evolution of scientific approaches to their conservation, and formed the methodological basis of the study. The second, analytical stage included a comprehensive assessment of the current state of legal support for the protection of ecosystems, analysis of statistical data, comparison of the experience of Ukraine and Lithuania in implementing environmental regulations, and identification of problems in the practical implementation of environmental legislation. At the third, scientific and practical stage, recommendations for improving legal regulation were developed, specific proposals for implementing international experience were formulated, and indicators for assessing the effectiveness of the proposed changes were identified.

A limitation of this study is that it focuses mainly on Ukraine and Lithuania and is supplemented by selected case studies from EU countries such as Germany and Copenhagen. While these case studies provide valuable insights into the protection of urban ecosystems, the geographical scope limits the applicability of the findings to regions with a different political, economic or cultural context. In addition, the study's reliance on EU directives, while helpful in understanding the regulatory framework in the EU, does not allow for a full appreciation of the global relevance or potential limitations of these directives, including implementation challenges and enforcement shortcomings. This narrow focus may reduce the broad applicability and usefulness of the study's findings in different global contexts.

Results

Theoretical and methodological foundations of legal regulation of ecosystem protection in the context of urbanisation

Emerging digital technologies, such as AI-driven surveillance and intelligent urban planning tools, present significant opportunities to surmount conventional enforcement obstacles in safeguarding urban ecosystems. As urbanisation escalates, these technologies offer a novel option to tackle environmental concerns that conventional

methods find difficult to solve. AI can be utilised to augment real-time environmental monitoring, hence enhancing the precision and responsiveness of regulatory enforcement. Moreover, intelligent urban planning instruments that amalgamate data from diverse sources empower cities to enhance resource utilisation and diminish ecological footprints more effectively. According to Chen *et al.* (2023) and Barton *et al.* (2021), the amalgamation of digitalisation, trade liberalisation, and new oversight mechanisms possesses considerable potential to revolutionise urban ecosystem management, fostering more sustainable and adaptable urban settings. This transition to digital solutions is essential for reconciling policy intent with practical enforcement, particularly in swiftly expanding urban regions.

In the context of rapid urbanisation, which is accompanied by a significant increase in the urban population and intensive transformation of landscapes, the legal aspects of protecting ecosystems affected by urban development are gaining special attention. The experience of EU countries, in particular Lithuania, demonstrates the importance of an integrated approach to the development of such a legal framework. The urban ecosystem, as a complex entity, is not a self-sufficient natural system, as it is formed through the interaction of natural components (vegetation, fauna, water resources, soil, air) with engineering and transport infrastructure, industrial facilities, residential areas, roadways, and communication systems (Figure 1) (Piera, Buil and Ginters, 2013; 2016; Kunakh *et al*., 2021).

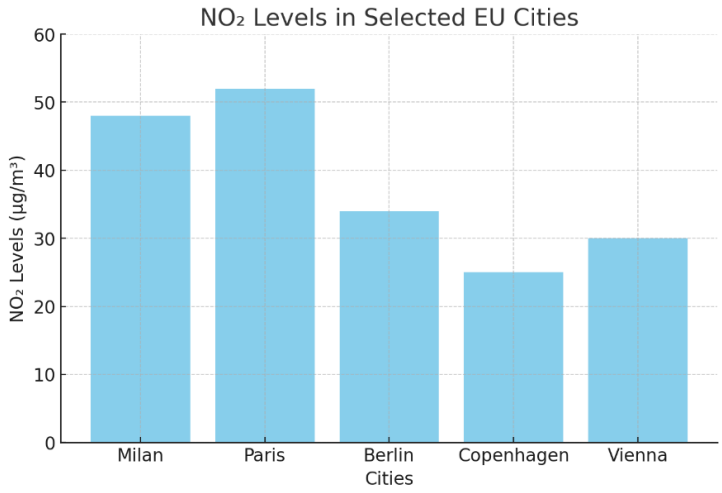

Figure 1: Comparison of NO_2 levels across selected EU cities

In the legal context, such an ecosystem is seen as a specific space where environmental interests, property rights, urban planning regulations and environmental policy intersect, aimed at preserving the environment, minimising harmful emissions and ensuring the balanced development of urban areas that meet the interests of current and future generations. A significant increase in building density and land use increases anthropogenic pressure, causing changes in the microclimate, lower air and water quality, depletion of green spaces, loss of biodiversity, increased noise levels and waste accumulation, and legal instruments to address these factors are becoming a priority (Lyubchyk *et al*., 2019; Shahini *et al*., 2023).

International and national environmental legislation is gradually shifting from a fragmented approach focused on individual environmental components to a holistic system of norms where urban ecosystems are recognized as an object of legal protection, which involves not only regulating the use of resources but also involving the public in decision-making, developing sustainable development plans, taking into account environmental standards when approving urban development projects, and implementing environmental impact assessment procedures. For example, the Law of Ukraine No. 1264-XII (1991)[9] set out the basic principles of environmental protection, and the Law of Ukraine No. 3038-VI (2011)[10] introduced regulations requiring consideration of environmental constraints in urban planning. An additional step was the adoption of the Law of Ukraine No. 2059-VIII (2017),[11] which provides clear procedures for analysing the potential environmental impacts of projects.

The integration of these legal norms emphasises the critical role of legal frameworks in supporting the sustainable development of urban ecosystems, acknowledging their complex structure and the necessity of ensuring their future resilience. Furthermore, European strategies and international agreements, such as the Aarhus Convention 1998,[12] provide essential guidance for developing a regulatory framework that not only sets environmental standards but also ensures public access to environmental information and justice. These frameworks also actively engage citizens in environmental decision-making processes, thereby promoting greater transparency and participation. Moreover, these frameworks support the development of "green infrastructure" and "green corridors" aimed at connecting fragmented natural elements within urban areas, facilitating their transformation into a cohesive, functional ecological network.

In general, the evolution of legal mechanisms for protecting the natural environment of cities is reflected in the transition from sporadic and poorly coordinated regulations to a more systematic approach. European law includes several directives that indirectly or directly affect the state of urban ecosystems. For example, Directive of the European Parliament and the Council No. 2008/50/EC (2008)[13] sets maximum permissible concentrations of pollutants in urban air and requires states to implement programmes to reduce emissions, control pollution sources and monitor air in urban agglomerations, which contributes to improved public health and a favourable environment. Council Directive No. 92/43/EEC (1992),[14] known as the Habitats Directive, is designed to protect natural habitats, rare and endangered species of plants and animals, which, in

[9] Law of Ukraine No. 1264-XII "On Environmental Protection". (1991). Available online at: https://zakon.rada.gov.ua/laws/show/1264-12
[10] Law of Ukraine No. 3038-VI "On Regulation of Urban Development". (2011). Available online at: https://zakon.rada.gov.ua/laws/show/3038-17
[11] Law of Ukraine No. 2059-VIII "On Environmental Impact Assessment". (2017). Available online at: https://zakon.rada.gov.ua/laws/show/2059-19
[12] Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters. (1998). Available online at: https://unece.org/DAM/env/pp/documents/cep43e.pdf [Accessed on 23 May 2024]
[13] Directive of the European Parliament and of the Council No. 2008/50/EC "On Ambient Air Quality and Cleaner Air for Europe". (2008). Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0050 [Accessed on 23 May 2024]
[14] Council Directive No. 92/43/EEC "On the Conservation of Natural Habitats and of Wild Fauna and Flora". (1992). Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31992L0043 [Accessed on 23 May 2024]

turn, is of significant importance for urban parks, botanical gardens, green spaces and other urban locations where certain biodiversity may be preserved.

The adoption of the European Green Deal (2019) and the Biodiversity Strategy for 2030 (2020) laid the groundwork for the development of long-term plans for urban nature restoration, the introduction of sustainable transport systems, the use of resource-efficient construction technologies, and the expansion of "nature-based solutions", i.e., solutions based on natural processes and reducing anthropogenic pressure. In particular, the European Green Deal emphasizes the need to preserve urban biodiversity, introduce green roofs and walls, create "green corridors" for the movement of wild species and ensure biomass circulation, while the Biodiversity Strategy for 2030 calls for large-scale restoration of degraded ecosystems, including urban ones, by expanding the network of protected areas, introducing environmental standards in urban planning and strengthening control over compliance with environmental legislation (Kovach *et al*., 2024). These acts not only set out the goals and principles of environmentally oriented policy, but also prescribe specific measures—such as noise level limits[15] and water quality standards[16]—that must be incorporated into national legislation, reflected in local strategic planning documents, and effectively implemented in practice.

When studying the legal status of urban ecosystems, it is necessary to take into account the multidimensionality of the problem: the combination of the legal sphere with the ecological, economic and social spheres. The use of legal hermeneutics, analysis of regulatory texts, comparison of legal systems of different countries and study of law enforcement practice in cities with different levels of urban development makes it possible to identify shortcomings in existing regulations, propose legislative updates, improve sanction mechanisms and increase the effectiveness of legal protection of the environment. The analysis of practical examples where new industrial or infrastructure facilities have caused an increase in the concentration of harmful substances in the air due to non-compliance with environmental requirements is supported by research and verified by official reports from the controlling authorities. This makes it possible to develop comprehensive legal mechanisms that respond to real threats to the urban environment. The use of a comparative legal approach, in which EU norms are compared with national laws and regulations, helps to find the optimal balance between mandatory regulation and flexibility in the legal field. For example, several European cities have introduced low-emission zones with stricter transport standards,[17] as well as environmental taxation and the polluter pays principle, which encourage businesses to be resource efficient and reduce their environmental footprint.

[15] Directive of the European Parliament and of the Council No. 2002/49/EC "Relating to the Assessment and Management of Environmental Noise – Declaration by the Commission in the Conciliation Committee on the Directive Relating to the Assessment and Management of Environmental Noise". (2002). Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32002L0049 [Accessed on 23 May 2024]

[16] Directive of the European Parliament and of the Council No. 2000/60/EC "Establishing a Framework for Community Action in the Field of Water Policy". (2000). Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32000L0060 [Accessed on 23 May 2024]

[17] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions No. COM/2021/400 "Pathway to a Healthy Planet for All EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil'". (2021). Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021DC0400 [Accessed on 23 May 2024]

In this context, it is illustrative to compare the experience of Ukraine and Lithuania, which, despite the common heritage of the Soviet period, demonstrate different paces and approaches to environmental transformation. In Lithuania, in the context of integration processes with the EU, the emphasis is on unifying regulations on biodiversity protection, water management, and regulation of industrial emissions in cities. Lithuania's environmental legislation includes Law of the Republic of Lithuania No. I-2223 (1992),[18] Law of the Republic of Lithuania No. I-1120 (1995)[19] and Law of the Republic of Lithuania No. I-301 (1993),[20] which is consistently updated to harmonise with the requirements of EU directives. In particular, the Law of the Republic of Lithuania No. I-2223 establishes the general principles of environmental policy and defines the powers of state authorities in the field of monitoring compliance with environmental standards, including in urban agglomerations.

Law of the Republic of Lithuania No. I-1120 regulates the establishment and management of areas of special environmental value, including urban green areas and environmental corridors. The Law of the Republic of Lithuania No. I-301 sets out requirements for integrated spatial planning, obliging municipalities to take into account environmental quality indicators and sustainable development principles when approving urban development projects. Such acts make it possible to strengthen the legal requirements for municipalities to preserve green spaces, create green corridors, and involve the public in making environmentally important decisions at the level of urban communities. Compared to Ukraine, Lithuanian legislation provides clearer mechanisms for controlling and holding developers accountable for non-compliance with environmental standards, and encourages resource-saving technologies in construction, as evidenced by the availability of tax breaks and grant programmes for renewable energy or permeable coatings projects.

At the same time, the basic provisions of environmental policy in Ukraine and Lithuania remain similar in terms of targets for air and water quality, waste minimization, and biodiversity conservation, but the Lithuanian regulatory framework has a higher degree of detail in the development of local environmental standards and the establishment of mandatory indicators (for example, the percentage of green areas in new projects). For Ukraine, it seems relevant to gradually adopt such experience, including the development of more specific criteria for the conservation and restoration of urban ecosystems, aligned with European principles of sustainable development.

By analysing these approaches, it is possible to formulate a conceptual model of legal protection of urban ecosystems, which will include a clear definition of the object of legal protection, establishing the responsibility of authorities for planning and control, developing effective procedures for environmental impact assessment and monitoring, involving the public and business in making environmentally important decisions, and applying flexible but effective legal instruments. The conceptual model is based on an integrated approach: a combination of legal norms with environmental standards, urban

[18] Law of the Republic of Lithuania No. I-2223 "On Environmental Protection". (1992). Available online at: https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/6378f2b0023211e6bf4ee4a6d3cdb874

[19] Law of the Republic of Lithuania No. I-1120 "On Territorial Planning". (1995). Available online at: https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/dde75b13095011e78dacb175b73de379?jfwid

[20] Law of the Republic of Lithuania No. I-301 "On Protected Areas". (1993). Available online at: https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.300377?jfwid=bkaxmpqm

planning regulations, infrastructure, transport and industrial requirements forms the legal foundation on which sustainable urban development can be built. Such a model takes into account existing international standards, in particular the UN Sustainable Development Goals,[21] implemented in the legal framework of states, and aims to achieve a harmonious balance between economic growth and the preservation of a quality urban environment that meets the fundamental human right to a clean and safe environment.

Thus, the development of the legal framework for the protection of ecosystems in the context of urbanization is a complex and dynamic process that includes the historical transformation of legislation, the formation of methodological foundations for research and the gradual development of a holistic, conceptually sound legal model capable of maintaining and restoring urban ecosystems, minimizing the negative impact of human activity and consolidating sustainable urban development as a strategic goal of modern environmental policy. The example of Lithuania confirms that a rational combination of legal mechanisms, economic instruments and public participation can accelerate the process of forming sustainable urban environments, and a comparative analysis of the legislative approaches of Ukraine and Lithuania allows us to identify the most effective practices and stimulate further improvement of national norms designed to protect urban ecosystems from excessive anthropogenic pressure.

Analysis of the current state of legal support for the protection of ecosystems in the context of urban development

The current regulatory framework governing the protection of ecosystems in urban areas consists of a multi-level system of international and national acts aimed at implementing sustainable principles of environmental management and maintaining ecological balance in the context of intensive urbanisation. At the international level, especially in the EU legal framework, a wide range of documents has been developed that set out criteria for the protection of biodiversity, air, water, soil and noise quality, and regulate the use of various ecosystem services in cities (Ginters, Mezitis and Aizstrauta, 2018; Kunakh *et al*., 2020; Moura *et al*., 2012). In particular, by introducing stricter requirements for municipal wastewater treatment, EU countries are stimulating the modernisation of water infrastructure, and by setting clear standards for industrial emissions, large industrial centres are gradually reducing their negative environmental impact. However, empirical evidence shows that despite the regulatory framework, about 90% of EU urban residents continue to be exposed to polluted air, and in some large agglomerations, such as Milan or Paris, nitrogen dioxide (NO_2) levels often exceed the established limits (European Environment Agency, 2020; 2021).

An analysis of the Lithuanian experience further shows that even in small countries with a relatively homogeneous urban development structure, the problem of uneven implementation of environmental regulations persists. According to the ministries responsible for the environment and spatial planning in Lithuania, EU requirements for wastewater treatment and industrial emissions regulation have been adapted in most large cities, such as Vilnius and Kaunas, but in some smaller municipalities, the level of control and compliance is insufficient. This example confirms the pan-European trend

[21] Resolution adopted by the General Assembly on 25 September 2015. (2015). Available online at: https://undocs.org/A/RES/70/1 [Accessed on 16 April 2025]

that macro-political goals need to be aligned with local circumstances, and that a lack of financial resources and institutional capacity can hamper the implementation of environmental regulations even when legally binding acts are in place. A visual representation of the current state and prospects of environmental policy in Ukraine and Lithuania until 2030 demonstrates a comprehensive approach to solving these problems (Table 1).

Table 1: Environmental policy of Ukraine and Lithuania for the period up to 2030

Politics	*Ukraine (current status)*	*Ukraine (2030 target)*	*Lithuania (current status)*	*Lithuania (2030 target)*
Renewable energy	4%	17%	28.1%	55%
Renewable sources in transport	2.47%	17%	6.69%	15%
Waste management	50% of waste generation (mainly landfill)	35% of waste generation (focus on reduction and recycling)	Traditional waste management	Transition to a circular economy
Water resources	87.1% coverage of centralised water supply	100% coverage	98.6% coverage	100% coverage (improved water management)
Renovation of buildings	3-5% of buildings modernised, 100,000 need thermal modernisation	Thermo-modernisation of 100,000 buildings, reduction of energy consumption by 50%	3,300 reconstructed buildings	9,500 buildings (€3.3 billion investment)
Greenhouse gas (GHG) emissions	Current emissions: 341.5 million tonnes of CO_2	Reach 35% of the 1990 level	+11% compared to 2005	-20.9% of the 2005 level
Energy efficiency (end-use)	49.4 million tonnes of oil equivalent	No more than 50.446 million tonnes of oil equivalent	5.7 million tons of oil equivalent	4.2 million tonnes of oil equivalent

Source: Law of Ukraine No. 2697-VIII "On the Basic Principles (Strategy) of the State Environmental Policy of Ukraine for the Period up to 2030" (2019),[22] European Green Deal (2019), Ministry of Environment of the Republic of Lithuania (2024).

[22] Law of Ukraine No. 2697-VIII "On the Basic Principles (Strategy) of the State Environmental Policy of Ukraine for the Period up to 2030". (2019). Available online at: https://zakon.rada.gov.ua/laws/show/2697-19

The table above reveals the differences in the approaches to environmental transformation between the two countries and demonstrates the different levels of ambition of their goals. The key feature is that Lithuania, as an EU member, sets much higher targets in the areas of renewable energy and greenhouse gas emissions reduction, while having a better starting point and access to substantial funding through European mechanisms. Ukraine, on the other hand, is focusing on fundamental infrastructure modernisation and improving basic environmental indicators, reflecting the real state of the economy and the country's current capabilities. The contrast in energy transformation is particularly striking, with a difference in renewable energy targets of almost 40 percentage points, highlighting the need to take into account the national context when formulating environmental policy and developing relevant legal mechanisms. The table allows us to identify not only quantitative differences in goals but also qualitative differences in approaches to environmental modernisation, which is critical for understanding the effectiveness of different models of legal regulation for protecting ecosystems in the context of growing urbanisation.

At the national level, including in Ukraine, legislation aims to integrate environmental goals into spatial planning and economic development of cities (Shults *et al*., 2023). However, formal regulations remain insufficiently detailed and are rarely supported by measurable indicators that would allow for an assessment of real progress. For example, current urban planning regulations set out the principles of taking environmental factors into account, but do not set minimum green space per capita. Statistical and demographic studies by the European Commission's Joint Research Centre (European Commission, 2023) show significant structural changes in Ukrainian cities, which put additional pressure on urban ecosystems and the spatial planning system. According to forecast scenarios, Ukraine's population may decline by 21-31% by 2052, depending on the dynamics of migration processes. The most optimistic scenario, "Migration Transition", envisages a 21% decline in the population, while the pessimistic scenario, "Prolonged War and Low Returns", predicts a 31% decline. The decline in the working-age population and young people will be particularly pronounced: by 2052, the number of people under the age of 20 is projected to be only one-third of that in 2022, even under the optimistic scenario.

At the same time, the share of the elderly population will grow, creating new challenges for urban planning and infrastructure development (Zasorin, Kurmangaliev and Ermukhanova, 2012). For example, the demographic burden ratio (the ratio of dependents to the working-age population) may increase from the current 50 to 70 dependents per 100 people of working age. Such demographic transformations require a revision of approaches to urban spatial planning and highlight the need to develop flexible mechanisms for adapting urban infrastructure to changing demographic conditions, especially in the context of ensuring environmental sustainability and the regenerative capacity of urban ecosystems. The use of demographic projections for Ukraine, such as those of the Joint Research Center, is limited because the ongoing conflict introduces significant uncertainty, making these projections potentially outdated and unreliable for accurately assessing future trends in urban ecosystem protection. This emphasises the need for caution when applying such projections in the context of the current geopolitical situation.

An analysis of the practice of applying legal mechanisms shows that even in the presence of formal requirements, the effectiveness varies significantly depending on the institutional capacity and economic potential of specific urban communities. According to studies, modern cities, which occupy only 3% of the earth's surface, are responsible for producing 50% of global waste, about 70% of greenhouse gas emissions, and 75% of energy and natural resource consumption (Bona *et al*., 2023; Turemuratov *et al*., 2024; Zhanbulatova *et al*., 2020). This put increasing pressure on rural areas and natural ecosystems to provide water, energy, and food. Research shows that the effectiveness of nature-based solutions depends heavily on an integrated approach to water management. For example, constructed wetlands can effectively remove pollutants and provide multiple ecosystem services, but their effectiveness requires proper maintenance and monitoring (Lyubchyk *et al*., 2015; Oral *et al*., 2020). In cities with an underdeveloped environmental control infrastructure, as evidenced by the low frequency of inspections and the lack of mobile environmental laboratories, it is more difficult to impose sanctions on violators, as the process of proving that environmental standards have been exceeded is cumbersome and time-consuming.

Examples from Lithuanian practice also show that financial and governance instruments play a key role. In some municipalities in Lithuania with a higher level of economic development (e.g., Vilnius and Kaunas districts), mechanisms for investing in green infrastructure are better developed. In particular, tax incentives are being introduced for businesses that implement rainwater harvesting systems and green roofs, and municipalities, together with NGOs, are implementing projects to ecologically restore water bodies and improve city parks. At the same time, in cities with lower incomes and less capacity to attract investment, legislative initiatives remain largely declarative, as they are not backed by material resources and professional staffing (Kravchenko and Tkachenko, 2024). This contrast reflects a common problem faced by Ukraine as well: the lack of a balanced approach to financial support for environmental measures may make it impossible to achieve the set regulatory targets at the local level.

The problematic aspects of legal regulation identified by empirical evidence include a partial lack of economic incentives that would encourage municipalities and the private sector to invest in ecosystem restoration and the introduction of resource-efficient technologies. According to a study by Burszta-Adamiak and Fiałkiewicz (2019), European cities that have introduced financial incentives for green roof owners have seen a significant increase in their adoption. In particular, in Germany, the annual increase in the area of green roofs is 13.5 million m2, and in Copenhagen, 200,000 m^2 of green roofs were created in 2010-2011 alone due to the inclusion of relevant requirements in local development plans. At the same time, where the legal framework is limited to declarative norms without specific financial support mechanisms, such as subsidies or grant programmes, the pace of implementation of such measures is much slower. This confirms the empirical assumption that the effectiveness of legal instruments increases when they are combined with economic, technological and managerial mechanisms.

A quantitative assessment of the effectiveness of legal mechanisms shows that where regulations define specific indicators, measurable targets and timeframes, monitoring results show real improvements in the state of ecosystems. For example, in some cities in Northern Europe that have set legislative targets to reduce nitrogen dioxide air

pollution by 15% over 3 years, actual measurements have confirmed that these targets have been met.[23] The empirical basis shows that the presence of clear parameters allows for a prompt assessment of the effectiveness of the measures taken, adjustments to policy, and improvements to the regulatory framework, making it more adapted to the dynamic conditions of the urban environment, which continues to evolve in the face of environmental challenges and socio-economic pressure.

It is important to note that there are weaknesses in enforcement, including resource constraints and corruption that significantly reduce the effectiveness of policy implementation, especially in urban governance. Lack of financial resources often prevents authorities from effectively monitoring and enforcing regulations, resulting in selective enforcement or complete disregard of specific policies. Moreover, corruption in law enforcement can exacerbate these shortcomings, as officials may ignore violations in exchange for rewards or fail to perform their duties impartially. These difficulties contribute to an atmosphere in which legislative frameworks and policies may appear meaningful in theory but lack the necessary tools for effective implementation. As a consequence, desired policy outcomes often go unachieved, undermining public trust and supporting poor governance. The analysis of the current state of legal support for the protection of ecosystems in the context of urban development reflects a complex and multidimensional situation. The article reveals the existence of an extensive legal framework that includes international, European and national acts, but its implementation is uneven. Empirical evidence suggests that where legislation is backed by clear indicators and incentive mechanisms, the results of ecosystem improvement are more visible. In contrast, a lack of institutional capacity, financial resources and transparent performance criteria often reduces the potential of legal provisions to a formality.

In comparing the methods of Ukraine and Lithuania to urban ecosystem protection and legislative restrictions, notable contrasts emerge, particularly in light of Lithuania's earlier admission into the European Union. Lithuania's environmental legislation has advanced significantly, notably through the adoption of EU standards addressing biodiversity conservation, water management, and industrial emissions, which have been incorporated at both national and local levels. The initial EU integration has allowed Lithuania to access significant EU financing and support, so expediting its implementation of ecologically beneficial practices. Conversely, Ukraine, despite progressing towards modernisation, continues to contend with political and economic instability, which has impeded the comprehensive execution of analogous programs. Ukraine prioritises essential infrastructure enhancements, including the modernisation of water and waste management systems. Although its environmental objectives generally align with those of the EU, its regulatory frameworks lack the specificity and substantial financial support mechanisms evident in Lithuania.

Additionally, Lithuania's legislative system is meticulously defined, with precise performance metrics and incentives for sustainable infrastructure, including green roofs and low-emission zones. This facilitates a more methodical and quantifiable method for

[23] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions No. COM/2021/400 “Pathway to a Healthy Planet for All EU Action Plan: ‘Towards Zero Pollution for Air, Water and Soil’”. (2021). Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021DC0400 [Accessed on 23 May 2024]

environmental conservation. Conversely, Ukraine's regulatory frameworks are sometimes vague, devoid of explicit, enforceable criteria and financial incentives, thereby undermining their efficacy in promoting sustainable urban environments. The disparities arise not just from Lithuania's historical adherence to EU environmental standards but also from Ukraine's continuous modernisation initiatives amidst geopolitical and budgetary obstacles. The observed divergence in environmental legal frameworks reflects the influence of earlier EU accession processes in Lithuania, contrasted with Ukraine's ongoing reforms amid post-crisis reconstruction and political challenges.

Improving legal regulation of ecosystem protection in conditions of urbanisation

Improving the legal regulation of ecosystem protection in the context of intensive urbanisation requires the development of a comprehensive system of norms capable of responding quickly to changes in the urban environment. Practical experience of EU countries shows that the most effective solutions combine specific legal requirements, clear quantitative indicators, open environmental data, economic incentives and effective sanctions. In this context, the systemic approach of "nature-based solutions", which integrates natural processes into transport, water infrastructure, landscaping, and construction by introducing appropriate regulations (permeable pavements, green roofs, low-emission zones, etc.) at the level of local regulations, deserves special attention.

Such measures not only optimise the microclimate and water balance of cities but also improve public health and contribute to climate change adaptation. The developed regulations must be based on objective monitoring data, supported by environmental impact audits, and provide for the availability of information to the public. This, in turn, necessitates the adaptation of national legislation to the requirements of key EU directives, such as Council Directive No. 92/43/EEC (1992),[24] Directive of the European Parliament and of the Council No. 2000/60/EC (2000), Directive of the European Parliament and of the Council No. 2002/49/EC (2002), Directive of the European Parliament and of the Council No. 2008/50/EC (2008) and the overall objectives of the European Green Deal (2019). Open environmental data and public involvement in decision-making contribute to strengthening public control, while economic incentives (tax breaks, grants) motivate businesses and municipalities to invest in environmentally friendly projects, minimising environmental impact.

Lithuanian practice shows the importance of an integrated approach, where legal mechanisms are harmoniously combined with organisational measures and financial instruments. In particular, in cities such as Kaunas and Klaipeda, municipal programmes provide for priority funding for environmental projects in coastal and lakeside areas to preserve unique natural complexes and prevent spontaneous development (Martire *et al*., 2022; Shahini *et al*., 2022). Due to this allocation of budget funds, developers are obliged to carry out a series of environmental audits, comply with stricter requirements for the preservation of green spaces, and, in case of destruction or cutting down of trees, pay increased compensation fees that are used to restore urban ecosystems. These procedures

[24] Council Directive No. 92/43/EEC "On the Conservation of Natural Habitats and of Wild Fauna and Flora". (1992). Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31992L0043 [Accessed on 23 May 2024]

are enshrined in special agreements between city councils and developers, which minimise legal gaps and ensure consistent monitoring of environmental obligations.

A similar approach is being followed in some EU cities, where "nature-based solutions" are officially enshrined in urban planning documents and receive comprehensive financial support. Local councils are introducing co-financing schemes for projects that reduce the anthropogenic burden on the environment and promote the development of green and blue corridors, and infrastructure development is taking into account environmental priorities. For Ukraine, which is in the process of harmonising its legislation with European standards, such examples can serve as a guide on how to combine environmentally oriented regulations with financial and organisational instruments to effectively address urban environmental problems. In practice, this means the possibility of applying various co-financing models, encouraging the development of permeable pavements, including mandatory nature-based solutions in tenders for the development or renovation of urban areas, etc. A table of specific measures and indicators has been developed to systematise and better understand practical steps to improve the legal regulation of ecosystem protection in the context of urbanisation (Table 2).

Table 2: Specific measures and indicators to improve legal regulation of ecosystem protection in the context of urbanisation

Activities	*Specific parameters/metrics*	*Expected effect*
Setting minimum areas of green space per capita	Minimum of 10 m^2 of green space per capita in densely populated areas, audited annually	Reducing the temperature background, improving air quality, and increasing the recreational attractiveness of urban space
Mandatory integration of 'nature-based solutions' into urban development projects	Implementation of permeable pavements in 70% of new road projects, use of green roofs in new buildings	Preserving the natural hydrological balance, reducing the risk of flooding, and creating a comfortable microclimate
Implementation of low-emission zones	Reduce the share of petrol and diesel cars to 30% by 2030 due to legal restrictions.	Reducing the level of air and CO_2 pollution, improving the health of residents
Strengthening air quality standards	Achievement of an average annual concentration of PM2.5≤10 μg/m^3, assessed annually	Reducing respiratory diseases, increasing life expectancy and overall environmental sustainability
Regular reporting and open environmental databases	Annual public reports on the state of air, water, noise, and green areas; open online access to data	Increased accountability, strengthened trust in government decisions, and increased public oversight and participation.
Economic incentives and sanctions	Tax incentives for renewable energy projects, fines for exceeding environmental standards	Increased investment in green technologies, reduced pressure on ecosystems, and a

Activities	*Specific parameters/metrics*	*Expected effect*
		positive economic and environmental cycle.
Adaptation of national legislation to the requirements of international directives	Incorporation of the Habitats Directive, Water Framework Directive, and Environmental Noise Directive	Harmonisation with international standards, improvement of protected areas, and reduction of offences
Improvement of monitoring and control mechanisms	Reduction in the number of recorded environmental violations by 20% over 5 years due to enhanced supervision	Prompt detection of threats, stabilisation of ecosystems, and more efficient application of legal norms

Source: Mikša *et al*. (2020)

The data presented in the table demonstrate a comprehensive approach to solving environmental problems in urban areas through the prism of legal regulation. Of particular value is the relationship between the proposed measures and specific quantitative indicators, which allows for an objective assessment of the effectiveness of the changes implemented. The system of indicators developed for each measure reflects the desire for measurability and specificity in achieving environmental goals. In particular, the establishment of clear parameters for the area of green zones, the percentage of implementation of nature-based solutions and restrictions on pollutant emissions creates a transparent system for assessing progress in implementing the city's environmental policy (Nurtazina *et al*., 2015).

Nature-based solutions (NbS) are strategies that use natural processes and ecosystems to solve urban and environmental problems, incorporating green infrastructure such as permeable sidewalks, green roofs and blue-green corridors (Oral *et al*., 2020). This approach aims to restore ecological balance in urban areas, promote biodiversity and increase resilience to climate change. As for the ecological modernisation theory, NbS is consistent with the principle of modernising society by integrating environmental concerns into the economic and technological development of cities. This theory advocates rethinking urban planning and infrastructure with resilience in mind, allowing the urban environment to adapt to climate challenges through natural processes rather than solely technological solutions. In addition, NbS intersects with environmental governance systems, emphasising the role of legal regulations, financial incentives, and public participation in the successful implementation of these solutions. The integration of NbS into legal systems and urban planning is supported by policy instruments, monitoring systems and data-driven governance models, ensuring that environmental sustainability is incorporated into urban development.

Another important aspect is the inclusion of economic incentives and control mechanisms, which ensure a balance between regulatory influence and market instruments. The proposed data structure in the table allows not only to track the current state of implementation of measures, but also to predict their long-term impact on urban ecosystems. In addition, detailing the expected effects of each measure allows for a better understanding of the potential impact of legal changes on the quality of the urban

environment and the well-being of the population, which is a crucial aspect in planning and implementing environmental initiatives in cities.

The application of these measures, supported by clear performance indicators, creates the basis for the development of a long-term policy for the protection of urban ecosystems based on transparency and scientific evidence. This approach enables constructive cooperation between state authorities, local governments, businesses, and the public. Lithuanian municipalities demonstrate practical experience in this context by taking on the role of coordinators of 'urban agroforestry' programmes: some abandoned or industrial areas are being transformed into green belts with the help of government subsidies and private investment. The main feature of such programmes is their complexity: from preparing the local regulatory framework (land management, selection of tree species, erosion control measures) to creating social spaces (recreation areas, bicycle routes, educational platforms), which expands the circle of stakeholders. For Ukrainian cities, this approach can be especially useful in terms of restoring areas that have been negatively affected by military operations or industrial degradation.

In practice, this model transforms the legal framework into a flexible mechanism for managing the urban environment, capable not only of maintaining existing environmental standards but also of responding effectively to the challenges posed by climate change, demographic fluctuations and industrial expansion. This creates a sustainable urban space where environmental risks are reduced, and the population exercises its right to a clean and safe environment. Summarising the experience of Lithuania and Ukraine, it is worth noting that the successful implementation of legal mechanisms depends on: a balanced combination of regulatory requirements and financial and organisational incentives; an effective monitoring and evaluation system (including environmental audits and open databases). Finally, it depends on the active participation of local communities that can catalyse nature-based solutions in urban planning projects.

The effectiveness of the legislative framework for conservation is significantly influenced by contextual elements, including corruption, public awareness and institutional capacity. Corruption can jeopardise the implementation of environmental legislation, lead to selective enforcement or complete disregard of restrictions, thus reducing their effectiveness. Public knowledge is necessary to gain support for environmental policies and to ensure public involvement and compliance with legal regulations. In the absence of public understanding and approval, even the most carefully crafted legislation may be resisted or not enforced. In addition, institutional competence is necessary for the effective implementation of the legal framework. Inadequate or underfunded organisations may not have sufficient technical expertise, personnel, or financial resources to effectively enforce and monitor environmental legislation. If not properly addressed, these variables can hinder the overall effectiveness of legal processes aimed at protecting ecosystems.

Discussion

This study of the legal aspects of ecosystem protection in the context of growing urbanisation has revealed the complex and multidimensional nature of the challenges

faced by cities in ensuring ecological balance. The results demonstrate that the effectiveness of legal regulation largely depends on the successful integration of environmental goals into spatial planning and economic development of cities, as well as on the establishment of effective mechanisms for the implementation of environmental legislation. This is consistent with the findings of Chen *et al.* (2023), who, based on the analysis of data from 30 provinces in China, found that a balanced approach to urbanisation that takes into account environmental factors contributes to the sustainable development of urban areas and improves environmental performance. The study by Chen *et al.* particularly emphasises the importance of digitalisation and trade openness as factors that positively influence the coordination between urbanisation and the environment.

Additionally, Wang, Zhan and Xin (2020), based on an analysis of international experience, propose a comprehensive governance framework that covers urban planning, industrial transformation, and institutional systems, based on successful practices from different countries, including the experience of Singapore, Japan, and European countries. Of particular value is the experience of implementing the garden city concept in Singapore and the zero-waste policy in Japan, which demonstrate the possibility of harmoniously combining urban development and environmental sustainability. An analysis of the current regulatory framework has shown that despite the existence of basic elements for the protection of urban ecosystems, legislation often remains insufficiently detailed and is rarely supported by measurable indicators, making it difficult to assess the effectiveness of the measures implemented. This observation is confirmed by the work of Kipāne and Vilks (2022), who note that despite a significant increase in the volume of environmental legislation in recent years, shortcomings in implementation and enforcement do not allow for effective environmental problem-solving. The researchers emphasise the need for a systematic approach and the importance of addressing the root causes of problems, not just the consequences.

Particular attention is drawn to the issue of integrating environmental factors into urban planning and zoning. Bansal and Pandey (2024) highlight the importance of zoning as a technological method of regulating pollution control mechanisms in urban areas, stressing the need to move from an anthropocentric to an ecological approach to urban planning. The researchers point to the successful experience of implementing environmental zoning in the UK, where a decentralised approach to strategic urban planning is applied, which allows for better consideration of local environmental features and community needs. An essential aspect of the study was the identification of the need to introduce nature-based solutions into urban planning and the creation of an appropriate legal framework for implementation. Conclusions of Pan *et al.* (2021), based on the example of Stockholm, demonstrate that the availability of ecosystem services is a key factor in urban development. The study emphasises the importance of place-specific strategies and the need to take into account spatial features when implementing nature-based solutions. Expanding on this idea, Haeri and Masnavi (2022) demonstrate the importance of process-oriented restoration of natural systems in urban environments using the example of urban river ecosystems. The researchers propose a comprehensive approach to urban river restoration that includes both technical and socio-ecological aspects.

An important addition is the work of Ehsanullah *et al.* (2021), who investigated the relationship between energy security and energy poverty in the context of climate change, which has a direct impact on the functioning of urban ecosystems. The practice of applying legal mechanisms demonstrates significant variability in effectiveness depending on the institutional capacity and economic potential of specific urban communities (Stenin, Drozdovych and Soldatova, 2020; Trofymchuk *et al*., 2022; Zuo, Cao and Teymurova, 2024). Grunewald *et al.* (2021), having analysed the experience of ten European cities, identified key barriers to the implementation of the ecosystem approach: lack of evidence base, lack of standardised methods for assessing natural benefits, and limited public involvement.

Mikša *et al.* (2020) complement this understanding by focusing on the importance of creating economic mechanisms to encourage private owners to implement sustainable land use, especially through payment for ecosystem services. The researchers emphasize the need to take into account local characteristics and cultural traditions when developing such mechanisms. A significant addition is the study by Alqahtany and Aravindakshan (2022), who, using the example of Saudi Arabia, demonstrated the importance of balancing the preservation of cultural heritage with the needs of urbanization, which is especially relevant in the context of protecting urban ecosystems.

The results of the study on the importance of harmonizing different policies and regulations are confirmed by Ahmed *et al.* (2022), who identified the problem of insufficient coherence between climate adaptation and urban planning policies in African cities. The study highlights the need for an integrated approach to adaptation planning and the importance of overcoming institutional barriers. Barton *et al.* (2021) develop this idea by proposing the concept of 'synchronizing logics' to better align research with policy needs, which is particularly important in the context of urban climate policy. A significant contribution to the understanding of this issue is the study by Sirakaya, Cliquet and Harris (2018), which analyses international legal instruments for the protection of biodiversity and ecosystem services in cities, including the Convention on Biological Diversity and the Ramsar Convention. Huang *et al.* (2021) demonstrate the importance of a systematic approach to optimizing urban ecological networks, emphasizing the need to analyse landscape characteristics and ensure ecological connectivity. The study shows that the effectiveness of an ecological network depends on the correct identification of sources of environmental impact and the establishment of appropriate connectivity corridors. This idea is confirmed in the work of Chen *et al.* (2023), who found a positive impact of digitalization and trade openness on the coordination between urbanization and the environment. The researchers emphasize the importance of introducing innovative technologies to monitor and manage urban ecosystems.

Additional confirmation of the identified patterns is provided by the study by Yasmeen *et al.* (2020), who, based on an analysis of 30 regions of China, found a significant impact of technological innovation and environmental regulation on the environmental performance of urban areas. The results show that the impact of urbanization on environmental efficiency varies depending on the level of development of the region – a positive impact is observed in the eastern regions with developed infrastructure, while in the central and western regions this impact is insignificant. This confirms the

conclusions of this study on the importance of taking into account the local context when developing legal mechanisms for protecting ecosystems. An important aspect that complements the understanding of ecosystem protection is the study by Kurowska *et al.* (2020), who analysed the impact of agricultural land and forest protection on spatial planning in Poland. The researchers found that urban development and the inevitable urbanization of rural areas lead to the loss of valuable land, which confirms the need to develop more effective legal mechanisms for the protection of natural areas in the context of urbanization. This is in line with the results of this study on the importance of integrating environmental requirements into urban planning at an early stage.

Foster and Bell-James (2024) focus on the legal barriers to ecological restoration, emphasising the role of law in supporting restoration efforts and the need for clearer legal frameworks, while identifying areas for further research in this field. The authors highlighted the importance of facilitative policy and governance frameworks, acknowledging the historically understudied legal barriers to restoration. The study summarised key considerations from existing literature to inform the development of effective legal frameworks for ecological restoration and identified areas requiring further research. In contrast, the current study on ecosystem protection in urbanisation explores the integration of environmental goals into urban planning and development, highlighting the importance of clear, measurable legal indicators.

Summing up the analysis, it can be stated that the results demonstrate the need for a comprehensive approach to the legal regulation of ecosystem protection in the context of urbanization, which considers both environmental and socio-economic aspects of urban development. This is in line with the general trend in international studies that emphasise the importance of integrating environmental factors into urban planning and the need to develop effective mechanisms for implementing environmental legislation. It is particularly important to strike a balance between the development of urban infrastructure and the preservation of natural ecosystems, which requires improving legal mechanisms, strengthening institutional capacity and developing a system for monitoring and assessing the environmental status of urban areas. A promising area for further research is the development of a methodology for assessing the effectiveness of legal mechanisms for protecting urban ecosystems and exploring the possibilities of adapting successful international practices to the local conditions of different cities and regions.

Conclusions

The study of the legal regulation of ecosystem protection in the context of urbanisation demonstrates the complex nature of this issue and confirms the need for a systematic approach to its solution. The results of the study show that in the context of rapid urban growth and increasing anthropogenic pressure on the environment, legal mechanisms for protecting ecosystems need to be significantly improved to ensure an effective balance between the development of urbanized areas and the preservation of the natural environment. A comparative analysis of the experience of Ukraine and Lithuania demonstrates different stages of development of environmental legislation and its adaptation to European standards. The analysis of the theoretical and methodological foundations, the current state of legal support and promising areas for improving the regulatory framework allowed us to form a holistic understanding of the challenges faced

by cities in the process of maintaining environmental balance and identify effective ways to overcome them through the improvement of legal mechanisms.

The research covered a wide range of aspects of legal regulation of ecosystem protection, including analysis of international and national legislation, study of practical experience in implementing environmentally friendly solutions, and assessment of the effectiveness of existing control mechanisms. Significant differences in the approaches of Ukraine and Lithuania to the implementation of environmental regulations were identified: while Lithuania has made significant progress in implementing European standards, in particular in renewable energy (55% by 2030) and the circular economy, Ukraine is focused on basic modernisation of its environmental infrastructure.

The study found that the current regulatory framework, while containing the necessary basic elements to protect urban ecosystems, needs to be significantly improved in terms of specifying requirements, establishing clear performance indicators, and developing effective incentive mechanisms. The study results confirmed that the most effective legal mechanisms are those that combine clear quantitative indicators, transparent monitoring procedures and economic incentives for the implementation of environmentally sound technologies. Particular attention was paid to the analysis of European experience, which demonstrates the effectiveness of an integrated approach to legal regulation of ecosystem protection through the introduction of low-emission zones, development of green infrastructure and strengthening the role of public control.

The results obtained are of significant theoretical and practical importance for the development of environmental law and urban planning legislation. The proposed conceptual model of legal protection of urban ecosystems, which includes a clear definition of the object of legal protection, establishment of the responsibility of public authorities, and development of environmental assessment and monitoring procedures, creates a methodological basis for further improvement of the regulatory framework. An important result of the study was the justification of the need to move from a fragmented to an integrated approach to legal regulation, which takes into account the interrelationships between different components of the urban environment and ensures a balanced development of territories.

The Lithuanian experience demonstrates the effectiveness of combining legal requirements with financial and organisational incentives, which can be used in the development of Ukrainian legislation. The developed system of specific measures and indicators provides a practical toolkit for assessing the effectiveness of legal mechanisms and their impact on urban ecosystems. However, for Ukraine, it is crucial to develop a tailored approach that addresses the unique challenges faced by Ukrainian urban environments. A key takeaway from the Lithuanian model is the need for a shift from a fragmented to an integrated approach to legal regulation, one that considers the interdependencies between various urban components and fosters balanced territorial development. This shift can be adapted to Ukraine's legal framework, but it must be done with careful consideration of local conditions.

This study offers a significant contribution to the study of the effectiveness of legislative mechanisms for the conservation of urban ecosystems, but it has its shortcomings. The

study relies predominantly on a limited set of case studies from Ukraine and Lithuania, which limits the applicability of the findings to regions with different political, economic and cultural contexts. The study's dependence on forecasts, especially for population change and prospective urban expansion, increases uncertainty due to the unpredictable nature of geopolitical circumstances, such as the ongoing crisis in Ukraine. These features underscore the need for caution in generalizing the results to different contexts. Subsequent research can broaden the scope of the study to include a wider range of case studies from different global contexts, allowing for a deeper understanding of the challenges and opportunities of urban ecosystem conservation. Moreover, the introduction of advanced technologies, such as artificial intelligence for environmental surveillance and automated law enforcement systems, can enhance the effectiveness of legal frameworks. Future research should explore the long-term implications of incorporating conservation solutions into urban planning, taking into account local socio-economic conditions and technological advances.

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Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	Author 1	Author 2	Author 3	Author 4	Author 5
Conceived and designed the research or analysis	No	Yes	No	Yes	Yes
Collected the data	Yes	Yes	Yes	No	No
Contributed to data analysis & interpretation	Yes	Yes	Yes	Yes	No
Wrote the article/paper	Yes	Yes	Yes	No	No
Critical revision of the article/paper	No	No	No	Yes	Yes
Editing of the article/paper	No	No	Yes	Yes	Yes
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